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EXPERIMENTAL INVESTIGATION OF VARIABLE COMPRESSION RATIO (VCR) DIESEL ENGINE PERFORMANCE AND CHARACTERISTICS OF EMISSION RATE OF COTTON SEED OIL BIODIESEL WITH TiO_2 AS A BIODIESEL BLENDS

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ABSTRACT

The energy empowered world demands energy from various increasing resources. The best energy alternative is offered by biodiesel to the evolutionary world. To reduce emission of diesel/ biodiesel blend and improve the engine performance, the metallic nanoparticles are added and had proven their effectiveness. This paper is focused on experimental investigation of Variable Compression Ratio (VCR) diesel engine and characteristics of emission rate of cotton seed oil biodiesel with TiO_2 as a different biodiesel blend. The merger proportion was B10, B20, B30, B40 and 100% diesel. Upbringing experiment, the testing was completed in a VCR diesel engine at 3.5KW in a constant speed engine. The TiO_2 were mixed into biodiesel blending proportion and it is used for reduction of emission compared to 100% diesel. The VCR engine performance at various loads at various levels is implemented for the investigation of emission characteristics. As the experiment gets carried on between brake power with specific fuel consumption and emission characteristics rate such as CO (carbon monoxide), NOx, CO_2, HC and supplementary gases. Hence, it is reported by the following experiment is absorbed that the use of cotton seed oil biodiesel with TiO_2 may well be awell-organized way of improving the engine performance and emission characteristics with diesel in addition to biodiesel blend. It was observed that the B10 and B20 biodiesel blends produce effects results with other blends in a SFC, BTE and emission characteristics such as CO emission, NOx emission, HC emission and CO_2 emission behaviour.

KEYWORDS: Titanium Dioxide, Carbon Monoxide, Hydrocarbon, Cotton Seed Oil, Specific Fuel Consumption, Carbon Dioxide & Brake Power

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Nomenclature

TiO_2 - Titanium dioxide

CO – Cotton seed oil

B10 – 10% biodiesel blend (90% of diesel + 10% of cotton seed oil+ 25 ppm)

B20 – 20% biodiesel blend (80% of diesel + 20% of cotton seed oil+ 25 ppm)

B30 – 30% biodiesel blend (70% of diesel + 30% of cotton seed oil+ 25 ppm)

B40 – 40% biodiesel blend (60% of diesel + 40% of cotton seed oil+ 25 ppm)

INTRODUCTION

The vitality requesting biodiesel is an anticipating fuel substitution in its place of non-renewable energy sources and it address the unnatural weather change issues. Bio diesel could be marketed when contrasted with other elective sources as it satisfies the propriety need and bolster the yield. The test tried nano particles and diethyl ether on

Original Article

biodiesel ethanol fuelled CI motor. They reason that including of titanium nano particles improved NOx, hydrocarbon and smoke with discouraged brake explicit fuel utilization and carbon monoxide. Including of zirconium nanoparticles developments brake explicit fuel utilization and hydrocarbon emanation with dropped carbon monoxide, carbon dioxide. Diminishing of NOx and smoke assigns the outcome of diethyl ether on low-threw temperature consuming [1]. A making of biodiesel from cotton seed oil and testing on little limit diesel motor experimentation was led. They infer that the kinematics consistency of diesel, squander cotton seed oil biodiesel discovered 2.8, 3.6 centistokes at 400C, the waste cotton seed oil biodiesel has kinematic thickness 75.09% an excessive amount of diesel. The left-over cotton seed oil biodiesel having high blaze and fire point and its shows discharge practices [2]. Performed outflow attributes of CI motor utilizing waste cotton seed biodiesel with ZNO as a fuel added substance and they contemplated four biodiesel mixes. They are reasoned that B25 blend springs more advantageous outcome contrast with others, resulting mix is tried with three extent of ZnO added substance in the following piece of the examination. The adding of 125 PPM of ZnO to the chose B25 mixes springs an improved exhibition, the proficiency upgrade is start to be 4.2% and the outflow of NOx is by 10.3% under complete burden condition [3]. Inquires about have been guided experimentation on impacts of nano metal oxide mixed Mahua biodiesel on CRDI diesel motor. They are infiltrating for appropriate other fuel for as long as barely any times and future a few elective fills, for example, bio-alcohols, vegetable oils, bio-gas and biodiesel. As a distinctive way, the biodiesel has become a hopeful fuel alternative due to advantages, such as biodegradable, renewable, easily availability of raw materials, easy producible and the properties of biodiesel nearer to the conservative diesel fuel [4]. The iron oxide nanoparticles fuel additive on exhaust emission and CRDI system were tested, they conclude that iron oxide nanoparticles blend reduced emissions and specific fuel consumption at all operating load, iron (II, III) oxide nanoparticles is an effective in enlightening performance, burning and plummeting the exhaust destructive pollutants from the CRDI system abetted diesel engine [5]. The graphene nano particles including various levels with simarouba biodiesel and diesel mixes on execution, burning and attributes of discharge pace of CI motor were tried. Improved brake warm productivity by 9.14%, decline in unburnt HC by 15.38%, CO by 42.855 and NOx discharge by 12.71% with SME2040 [6]. Considered the impact of dispersal of different nano added substances on the improvement of the exhibition and outflow decline qualities of a CI motor fuelled with diesel, biodiesel, and its mixes were tried. They are reasoned that development in NOx when nano added substances are blended in with unadulterated diesel because of expanded pinnacle temperature and CO emanation diminishes due to finish start of the fuel [7]. The specialist tried impact of VCR diesel motor highlights utilizing mixes of cottonseed oil with nano added substances. They presume that aggregation of CeO2 nanoparticles the particular fuel utilization (SFC) of fuel is diminished up to 13.8%. Brake warm proficiency (BTE) is upgraded up to 8.3% by mixing cottonseed oil and CeO2 nanoparticles in Biodiesel. Biodiesel orchestrated with cottonseed oil on expansion cerium Oxide nanoparticles has higher calorific worth, flashpoint and fire point. Frequency of CeO2 in Biodiesel has condensed hydrocarbon (HC) and carbon monoxide (CO) outflow by 39.3% and 18.4%, separately. Smoke from the fumes is diminished for the explanation that expanded ignition rate. The presence of CeO2 and cottonseed oil in biodiesel fuel execution of Biodiesel mixes at B20 and B30 has sensible proficiency identified with 100% diesel [8]. The test drove on diminished NOx outflow by fuelled with biodiesel and diesel motor execution. They reason that the including of nano particles underpins the expanding the fuel properties and diminishing the fumes emanations [9]. The algal biodiesel and its mixes on a diesel motor were tried and presume that the AB30 mix showed the base drain discharges. The discharges NOx, CO2 and O2 improved up to 25–30%, 9–20% and 8–20% correspondingly inferable from carbon chain and oxygen content in methyl ester [10]. The trial directed on D.I diesel motor utilizing custard apple biodiesel. The custard apple biodiesel

utilizing transesterification strategy got and various mixes (B10, B20, B30 and B40) are arranged and blended in with traditionalist diesel fuel. They are presumed that biodiesel as of custard apple seeds uncovered created brake warm proficiency and diminished CO, CO2 and HC emanations and augmented NOx outflow, and they are found B20 and B30 is reasonable biodiesel mix [11]. Right now, cotton seed oil biodiesel with TiO2 (Titanium dioxide) in an alternate biodiesel mixes with utilization of Variable Compression Ratio (VCR) motor has been assess. This assessment of mixes was acquired from the Variable Compression Ratio motor. The accompanying exhibition was gets completed like brake power with explicit fuel utilization and attributes of discharge rate, for example, CO (carbon monoxide), NOx, CO2, HC and different impacts.

METHODOLOGY

Properties of TiO_2

The Titanium dioxide particle added into biodiesel blends and their properties listed in the table 1. It has density 4.23 g/ cm^3 and it in soluble in water.

Cotton Seed Oil Biodiesel Production

The cotton seed collected from Perungalathur shop, Chennai, India. The cotton seed was cracked to eliminate the cotton shells subsequently the oil-bearing nuts were washed in distilled water and dried in sunlight for about 7days. The dried cotton seed nuts were then treated in an oil expeller to excerpt the crude cotton oil. After the crude cotton oil is taken out, it was converted into biodiesel by transesterification method. This method used an apparatus in which the crude cotton seed oil was poured and heated up to 75°C using an electric heater while continuously rousing with the help of a magnetic stirrer. After that, methanol (20% of cotton seed oil) and KOH (3%) were added to it and allowed the mixture to react for about 20 min. Later the reaction was complete, the biodiesel was removed from the reactor, washed it in distilled water to remove the chemicals, and heated to remove the traces of water particles. The resulting cotton oil biodiesel was used for the experimentation. The properties of diesel, crude cotton seed oil, cotton seed oil biodiesel was tested and tabulated as shown in table 2. The cotton seed oil tested obtained result as density of 920 Kg/m^3, flash point of 220^0C and fire point of 210^0C.

Biodiesel Fuel Blends

B10 – 10% biodiesel blend (90% of diesel + 10% of cotton seed oil+ 25 ppm)

B20 – 20% biodiesel blend (80% of diesel + 20% of cotton seed oil+ 25 ppm)

B30 – 30% biodiesel blend (70% of diesel + 30% of cotton seed oil+ 25 ppm)

B40 – 40% biodiesel blend (60% of diesel + 40% of cotton seed oil+ 25 ppm)

Experimental Procedure

In this work, four (4) type of biodiesel fuel blends were used to determine the effect of cotton seed oil biodiesel with titanium dioxide on the engine performance and characteristics of emission. The fuel blends were prepared and the B10, B20, B30 and B40 fuel blends has 10%, 20%, 30% and 40% of biodiesel blend. Then, 25ppm is added to each fuel blends.

The VCR exploratory arrangement is appeared in Figure 1. A Kirloskar VCR diesel motor of 3.5 kW power rating was utilized with motor details as appeared in table 3. The motor was joined with a swirl current dynamometer that can be

utilized for getting diverse weight conditions. The dynamometer area was balanced with an electronic circuit associated with a minicomputer. The AVL Digas 444 gas analyser, equipped for estimating the emanations of CO2, NOx, HC, CO and O2, was utilized to sum the release levels of these expend gases. The motor was in progress and allowed to run for around 3 min so as to warm the motor alongside to run the motor at a persistent motor scurry of 1500 rpm. This scramble was kept up consistent during the examination. The presentation physical appearance of the motor was examined. The brake warm proficiency, brake explicit fuel utilization, and outflow attributes were inspected as much as CO, HC, CO2 and NOx discharges.

Uncertainty investigation

The apiece experimentation was tested three times, and the average of three readings was tabularized in order to rise the exactness of readings and to eradicate the uncertainty errors. Uncertainties in the experiments can rise from instrument choice, condition, observation, environment, calibration, test planning, and reading. The uncertainty investigation was carried and the parameters listed in table 4.

$$\text{Whole Uncertainty} = \sqrt{(U^2_{BP} + U^2_{BTE} + U^2_{BFSC} + U^2_{L} + U^2_{S} + U^2_{FFR} + U^2_{AFR} + U^2_{CO} + U^2_{HC} + U^2_{NOx})}$$

$$\text{Whole Uncertainty} = \sqrt{(0.5^2 + 0.6^2 + 0.6^2 + 0.2^2 + 0.2^2 + 0.5^2 + 0.5^2 + 0.4^2 + 0.6^2 + 0.9^2)}$$

$$\text{Whole Uncertainty} = \pm 1.69\%$$

Table 1: Properties of TiO_2

Parameters	Values
Molecular formula	TiO_2
Molar mass	79.866 g/mol
Appearance	White solid
Density	4.23 g/ cm^3
Melting point	1843^0C
Boiling point	2972^0C, 3245 K
Solubility in water	Insoluble

Table 2: Diesel, Cotton Seed Oil and Biodiesel Fuel Properties

Properties fuel	ASTM standards	Diesel	Cotton seed oil	Biodiesel
Density(Kg/m^3)	ASTM D1298	850	920	890
Kinematic viscosity at 40^0C (cSt)	ASTM D445	3.0	30.5	6
Calorific value(MJ/Kg)	ASTM D240	43	38	40.5
Flash point(^{0}C)	ASTM D93	60	220	125
Fire point(^{0}C)	ASTM D92	70	210	125

Table 3: VCR Engine Specification

Engine Model	VCR Diesel Engine
Cooling system	Water cooled
Swept volume	660.45 cc
Compression ratio	20
Connecting rod length	230 mm
Stroke length	115 mm
Cylinder bore	88 mm
Number of strokes	4
Number of cylinders	1
Speed	1500 rpm

Maximum power rating	3.5 KW
Overall dimensions	W 2000 × D 2500 × H 1500 mm

Table 4: Uncertainty of the Measured Parameters

Measured Parameter	Un Certainty Level (%)
Brake power	± 0.5
Brake Thermal Efficiency (BTE)	± 0.6
Brake Specific fuel consumption (BSFC)	± 0.6
Load (L)	± 0.2
Speed (S)	± 0.2
Fuel Flow Rate (FFR)	± 0.5
Air Flow Rate (AFR)	± 0.5
CO	± 0.4
HC	± 0.6
NOx	± 0.9

Figure 1: VCR Kirloskar Engine Setup.

RESULTS AND DISCUSSIONS

The cotton seed oil biodiesel mixes with titanium dioxide analyze effectively tried in the utilization of VCR Kirloskar motor arrangement. The outcome is drawn as a chart and result are talked about with assistance of figure 2, 3, 4, 5, 6 and 7.

Figure 2 shows the particular fuel utilization versus BP. This shows the expanding BP just as the SFC additionally get expanded. In the 1.5 KW BP organize the B10 and B20 has less measure of SFC contrasted with other biodiesel mixes with titanium dioxide. In the last phase of 5.5 KW BP has B10 and B20 have less SFC contrasted with 100% diesel and B30, B40. At long last, the SFC versus BP diagrams shows B10 and B20 having less SFC when expanded BP.

Figure 3 shows a chart of BTE versus BP for the few biodiesel mixes. The chart shows expanding BP with increment of BTE. The B10 and B20 biodiesel mixes having high BTE contrasted with different mixes. The 100% diesel shows the less BTE in the expansion of brake power. At last, this demonstrated B10 and B20 have high BTE with increment of BP.

Figure 4 shows the carbon monoxide outflow charts with BP. It saw that the B10 and B20 biodiesel mixes shows the lowermost emanation rate identified with another biodiesel mix and 100% diesel. This shows expanding BP with diminishing CO discharge. The 100% diesel and B40 fuel mixes shows the high discharge rate.

The figure 5 shows the hydrocarbon outflow diagram with BP in KW. This diagram shows expanding BP with expanding HC discharge. This is chart shows that B10 and B20 have less HC outflow contrasted with l00 % diesel and B30 and B40 cotton seed oil biodiesel mixes. The 100% diesel has more HC discharge rate contrasted with B10, B20, B30 and B40. Figure 6 shows CO_2 emission with BP graph. This shows that increasing BP with an increase in carbon dioxide emission rate. The result was showed B10 and B20 biodiesel blend has less emission rate compared to remaining blends and 100% diesel. The 100% diesel shows high emission rate with increasing BP.

Figure 7 shows the NOx emission graph through brake power. This obtained result of B10 and B20 biodiesel blend has less emission rate with increasing BP as well as increasing NOx. The 100% diesel showed high emission rate in form of increased BP with increased NOx compared to other biodiesel blends.

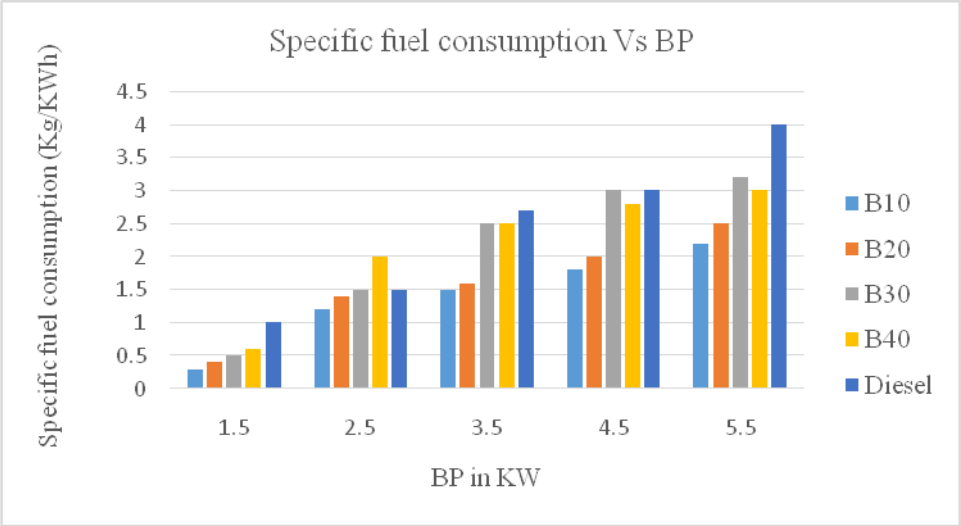

Figure 2: Specific Fuel Consumption Graphs.

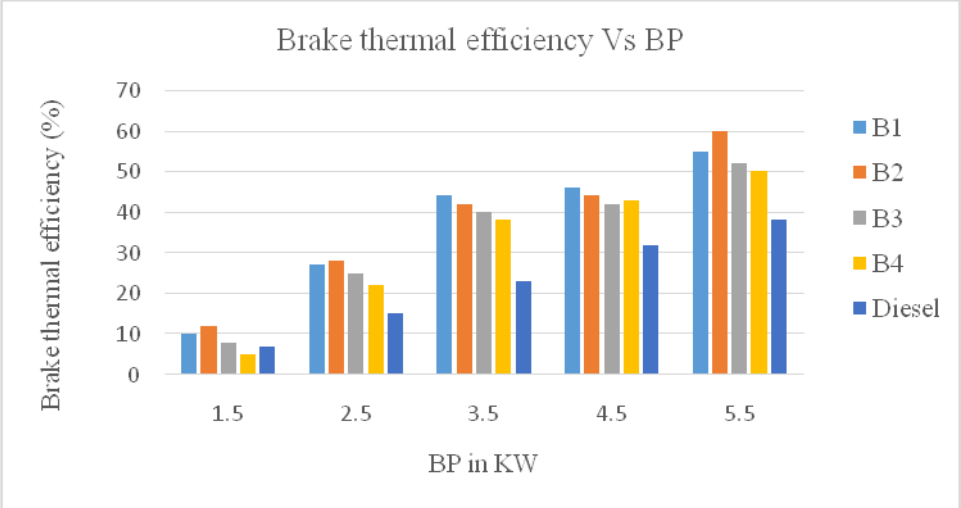

Figure 3: Brake Thermal Efficiency Graph.

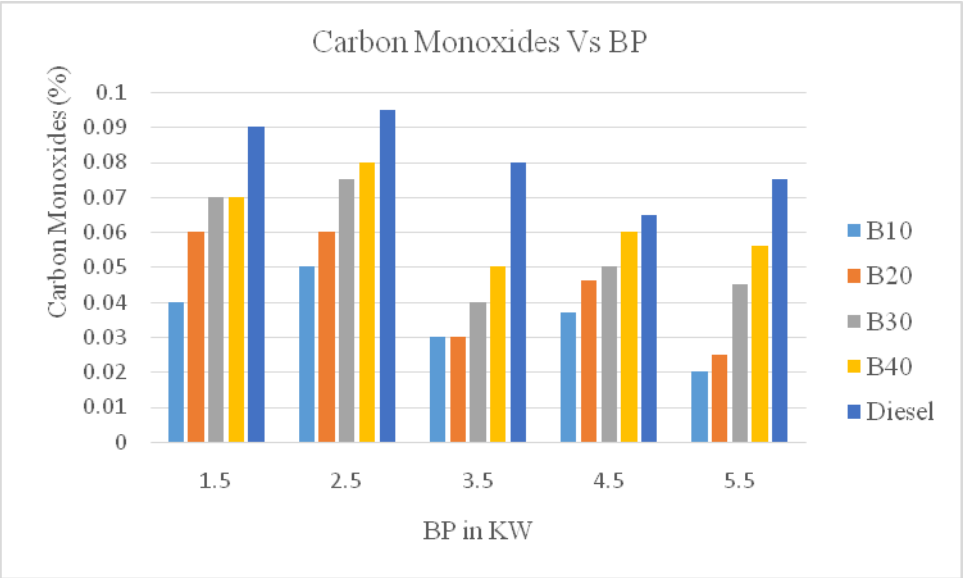

Figure 4: CO Emission Graph.

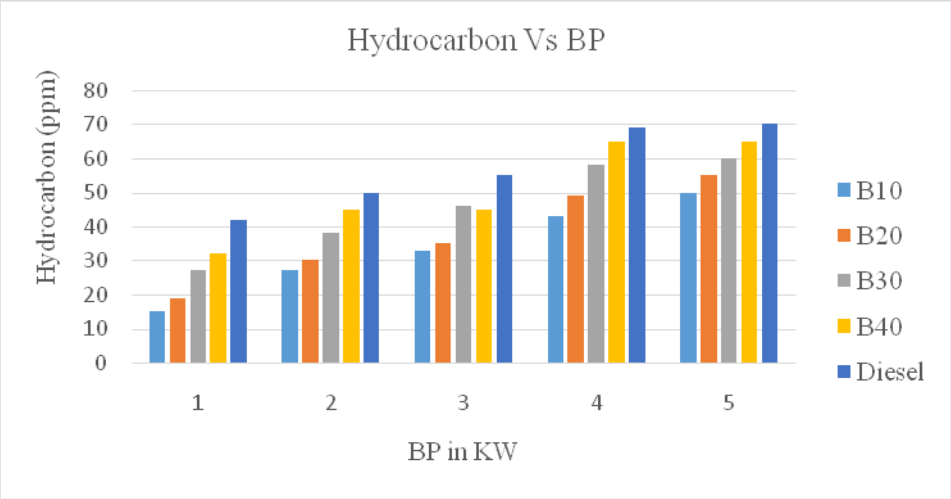

Figure 5: Emission of HC Graph.

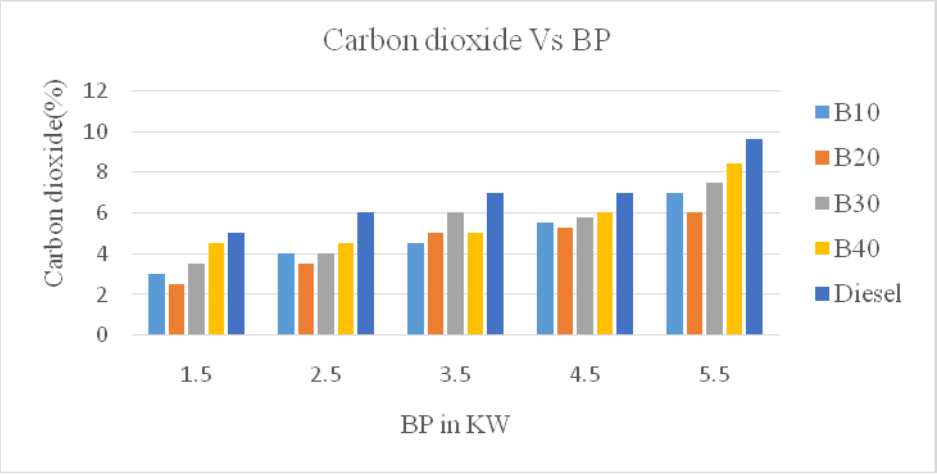

Figure 6: Carbon dioxide Emission Graph.

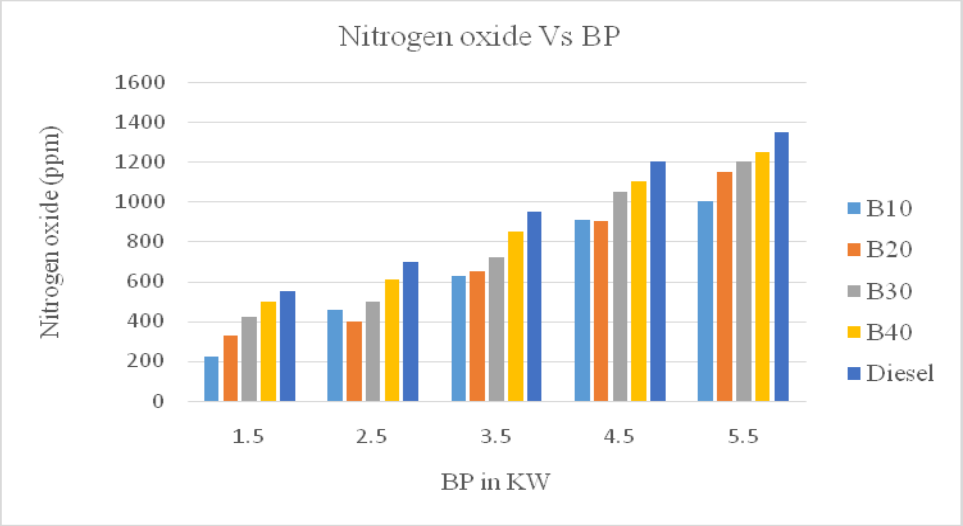

Figure 7: NOx Emission Graph.

CONCLUSIONS

The experimental examination of Variable Compression Ratio (VCR) diesel engine and emission characteristics of cotton seed oil biodiesel with titanium dioxide in a biodiesel blends were test. The following result were obtained during the examination.

- This shows that the increasing BP as well as the SFC also get increased. Finally the SFC vs BP graphs show B10 and B20 having less SFC during increased BP.
- The 100% diesel shows the less BTE in the increase of brake power. Finally, this showed B10 and B20 have high BTE with an increase of BP.
- It observed that the B10 and B20 biodiesel blends shows the lowermost emission rate compared to another biodiesel blend and 100% diesel.
- The 100% diesel have more HC emission rate compared to B10, B20, B30 and B40.
- The result was showed B10 and B20 biodiesel blend has less emission rate compared to remaining blends and 100% diesel. The 100% diesel shows high emission rate with increasing BP.
- The 100% diesel showed high emission rate in form of increased BP with increased NOx compared to other biodiesel blends.

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